

World Nuclear Association Annual Symposium
7-9 September 2005 - London

Powering Canada's Economic Heartland - Is there Life After Coal?

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Abstract

There has been a flurry of activity in the Ontario electricity sector over the last 18 months as the government continued to work at averting a major crisis of supply in Canada's most populous province and industrial heartland.

As stated by the Ministry of Energy last year, "*Ontario needs to refurbish, rebuild, replace or conserve 25 000 megawatts of generating capacity by the year 2020 to meet growing demand while replacing its polluting coal-fired generating plants. That represents 80 per cent of Ontario's current generating capacity and would require an investment of \$25 to \$40 billion.*"

Action has been taken. The government has now completed a restructuring of the electricity market with new legislation and has undertaken a number of major initiatives in providing new supply. These include: contracts for 395 MW of renewables supply and a new Request for Proposal (RFP) for another 1000 MW, conclusion of a tender for 2500 MW of new gas supply and conservation, commitment to the restart of Pickering Unit 1 and the refurbishment of Bruce Units 1 & 2, consideration of new supply in neighbouring Manitoba and Quebec and expansion of the hydro station at Niagara Falls.

Nuclear power continues to be the backbone of the Ontario electricity system, providing about 40% of its supply. Coal generation, currently representing about 25% of the supply, provides key intermediate load in the province. The commitment by government to stop burning coal by 2009 increases the stress on the already strained system. This paper will examine government's plan to meet the needs of the province, including an independent perspective on the ongoing role for nuclear power, for both refurbishment of the existing fleet and the potential for new build, and will present an alternative scenario for consideration.

Introduction

In June of 2004, Dwight Duncan, the Minister of Energy of Ontario, Canada announced, "*After more than a decade of mismanagement in Ontario's electricity sector, our ability to keep the lights on has been compromised. It is absolutely critical that we move forward quickly to boost new supply, increase conservation and maintain price stability for consumers so that we can ensure continued prosperity in the province.*" [1]

Ontario had an aging electricity supply and distribution system, a market that was not working and its major generating company, Ontario Power Generation (OPG), was suffering from years of ineffective restructuring and political uncertainty. To add to the problem, the Ontario government made a pledge to replace all of the coal generation in Ontario, representing close to 25% of the supply (*Table 1*), with more environmentally acceptable alternative generation. This, coupled with a nuclear fleet that was nearing its end of life, made it clear that the electricity sector in Ontario was in crisis.

As stated by the Ministry of Energy, "*Ontario needs to refurbish, rebuild, replace or conserve 25 000 megawatts of generating capacity by the year 2020 to meet growing demand while replacing its polluting coal-fired generating plants. That represents 80 per cent of Ontario's current generating capacity and would require an investment of \$25 to \$40 billion.*" (*Figure 1*). Quite a daunting task!

The Ministry has taken action to address this critical issue, making announcements almost continuously over the past year related to the electricity sector. This new direction resulted in a strong commitment to conservation, the announcement of numerous initiatives to increase supply and a complete restructuring of the electricity sector through the introduction and passage of Bill 100.

Bill 100 reorganized the sector, with one of its key outputs, the creation of the Ontario Power Authority (OPA) to act as a central planning authority for the province, and to contract for generation if and when needed. The OPA will be the entity issuing Request for Proposals (RFPs) on behalf of the government from this point on (Note: earlier RFPs for renewable energy and clean energy supply were issued directly by the ministry since the OPA had yet to be formed). The objective was to create a new hybrid electricity market, partly regulated and partly open to market forces. The OPA is now in place, adding staff and starting the work necessary to fulfil its mandate).

New Supply

Over the past year, the Ontario government has made a number of decisions and implemented projects designed to increase the supply of electricity in the province. To date, they have concluded 4 major initiatives:

- Approval of a new tunnel at Niagara Falls. This will enable an increase of 1.6 TWh per annum (200 MW) [2].
- Approval of the restart of Pickering Unit 1 (515 MW) [3].

- Completion of the RFP process known as Renewables I – which resulted in 395 MW of new commitments (31 MW hydro, 315 MW Wind and 47.1 MW landfill gas, and one small project still subject to approvals) [4].
- Completion of the RFP process for Clean Energy Supply – which resulted in 2235 MW (2135 MW of gas, 90 MW of cogeneration and 10 MW of demand response) [5].

The above represents a commitment to **3345 MW of new generation**. In addition to the above, the government announced the conclusion of preliminary negotiations with Bruce Power for the restart of Bruce Units 1 & 2, which would result in an additional 1540 MW, and has undertaken a detailed technical study with Manitoba on new hydro, which could provide up to 1500 MW of new power to Ontario.

More recently the government has issued the RFP for Renewables II – for 1000 MW of additional renewable energy supply [6]. The bids are due in August with a decision to be made by November. And on 12 July, the first draft of the RFP for Renewables III was issued for public comment – for another 200 MW of renewable energy.

The above initiatives, if all successful, would result in an increase in supply of more than 7500 MW of power, enough to replace the existing coal generation capacity for the province. Of course, it is not yet clear if all of the above is achievable. But nonetheless, it is a formidable achievement by the government of Ontario within a relatively short period of time.

The Plan to Replace Coal

On 15 June 2005, the Ontario government issued its plan for the replacement of Ontario's coal units [7] representing 7578 MW of capacity. The plan delayed the original promise somewhat, with the last units being retired in 2009 rather than in 2007. Overall, the schedule for replacement is as follows:

- Lakeview GS (1140 MW) was closed on 1 April 2005;
- Thunder Bay GS (310 MW) will close in 2007;
- Atikokan GS (215 MW) will close in 2007;
- Lambton GS (1975 MW) will close in 2007;
- Nanticoke GS (3938 MW) will have units closed through 2008 with the last unit to close early in 2009.

The base plan for the replacement of these units is illustrated in *Figure 2*. Note that in addition to new supply, there is a need for transmission upgrades to achieve the closure of all units. In its recently released 2005 10-Year Outlook [8], the IESO states that “*This transition [from coal] represents the largest and most significant electricity system change ever undertaken in Ontario and involves major technical considerations. It also involves significant risks and challenges that need to be addressed.*”

From *Figure 2*, it can be seen that the plan to replace the coal units consists of the 3345 MW already committed, plus the following new generation. Some of these initiatives are underway and others have yet to be started.

- Renewables RFP II (1000 MW).
- Renewables RFP III (200 MW).
- Replacement of Thunder Bay GS with gas (310 MW).
- New co-generation (1000 MW).
- Downtown Toronto new generation of undetermined type (500 MW).
- West GTA new generation of undetermined type (1000 MW).
- Conservation initiatives (demand side management and demand response – 250 MW).

The above add up to 4260 MW of new generation added to the already committed 3345 and totals 7605 MW to replace a total coal generation prior to any closures of 7578 MW.

The proposed restart of the Bruce units would bring in another 1540 MW, but this is not considered as part of the base scenario, as announced by government. It is also interesting to note that the potential restart of the remaining two nuclear units at Pickering (Units 2 and 3) are not mentioned at all. These units represent the potential for another 1030 MW and they are located in the GTA (Greater Toronto Area), which is of critical importance to the system.

What are the risks associated with this plan? The following provides some discussion on some of the projects and their potential impact.

Niagara Tunnel

Figure 2 attributes 200 MW to the expansion at the Sir Adam Beck hydro station at Niagara Falls. This new tunnel will enable an increase in generation of 1.6 terawatt-hours of energy per year. However, this is an energy-only project and does not represent an increase in capacity. Therefore, it cannot directly replace capacity towards meeting the peak requirements in the province.

Renewables

The response to the RFP Renewables I was very successful with contracts being let for 395 MW, higher than that specified in the RFP (300 MW). Of the 395 MW, 315 MW is wind generation. Wind's contribution to the grid cannot be compared to coal on a one-to-one basis due to the intermittency of the resource. This has an impact on both capacity and energy. The IESO has recently completed a study on the impact of wind generation on the Ontario electricity system [9]. This study concludes that "the overall capacity value of wind on the Ontario electricity system appears to be around 37 to 40%." Even with this conclusion, the most recent IESO 18 month outlook [10] makes the more conservative assumption that wind has a 10% capacity value until there is actual

operating data to support the higher numbers. Therefore, even making a more aggressive assumption and accepting the higher value in the IESO study (40%), the 395 MW will have a replacement value of 206 MW.

In the Renewables II RFP, which is currently being bid, it is reasonable to assume that most of the projects are likely to be wind farms, as the RFP is targeted at larger scale renewable projects. The RFP also recognizes that it may not achieve the full 1000 MW. The RFP clearly states that when the bidding projects are ranked from lowest price to highest, projects that exceed 115% of the average price of the first 450 MW will not be selected, even if that means that the 1000 MW will not be reached. Therefore, even making the more optimistic assumption that the 1000 MW will be reached, primarily with wind, would result in this 1000 MW achieving a replacement value of 400 MW.

The Renewables III RFP is for 200 MW and is targeted towards small-scale wind and small-scale hydro. In a similar pricing scheme to Renewables II, the RFP is only committed to selecting the first 90 MW depending upon price. However, assuming that the full 200 MW is contracted and that half will be hydro and that half will be wind, the capacity value would be 140 MW.

Gas

The result of the Clean Energy Supply (CES) RFP was a commitment to new gas projects of 2135 MW. The coal replacement plan identified in *Figure 2*, calls for another 310 MW of gas, plus the downtown and west GTA projects (fuel type yet to be determined) achieving another 1500 MW. These are most likely to be gas as well.

In order to assess whether or not an additional 1810 MW of gas is reasonably achievable, the success of the 2500 MW CES RFP must be considered. The 2500 MW RFP had a very large number of bidders, 33 bidders representing over 8800 MW of generation. Yet the result of the RFP was contracts for only 2235 MW (including co-generation and demand response), somewhat less than the 2500 MW requested. This was a price decision since the Ministry did reserve the right to select a smaller number of MW, based on the price of the projects. Resource adequacy is also an issue. During the winter peak, gas use will be at its highest as it is used for direct heating in addition to the generation of electricity. On this basis, increasing the gas component by another 1810 MW will be a challenge.

Co-generation

Following the selection of one co-generation project (Greater Toronto Airport Authority Project, 90 MW) as part of the CES RFP, the province is now preparing to implement co-generation on a much larger scale. Co-generation is a very attractive form of generation, but at this time, based on experience to date, the target of 1000 MW is aggressive. If it is assumed that the most likely fuel for co-generation facilities would also be gas, this increases the gas requirement to 2810 MW in addition to the already committed 2135 MW.

Demand Side Management and Demand Response

Conservation has been a very important part of the strategy to address the electricity supply issues in Ontario. A Chief Conservation Officer has been appointed at the new OPA and there are many initiatives underway to try and get Ontarians to reduce their electricity usage.

Demand side management and demand response were key elements of the 2500 MW CES RFP. Yet, of the 2235 MW finally contracted, only 10 MW were for a demand response project. Can another 250 MW be achieved in this time frame?

The Issue of Price

On 27 April 2005, the Ontario government issued a study [11] that demonstrates the economic impact to the province of electricity generation using coal. This study considers the total economic impact, including the generation cost, as well as the health and environmental costs resulting from the pollution emitted from burning coal. The study found that pollution caused by coal generation could be attributed to up to 668 premature deaths, 1100 emergency room visits and 333 660 minor illnesses per year. It concludes that a system comprising a mix of gas and refurbished nuclear has a lower total cost to Ontario society when compared with the status quo. The annual cost including health and environmental costs with coal is \$4.4 billion and a system comprised of gas and refurbished nuclear costs \$1.9 billion.

However, these costs are incurred in different sectors of the economy. At this time, coal is a low cost generation alternative, when only considering the costs of generation (about \$37/MWh). Therefore, removing coal and replacing it with cleaner alternatives, will result in higher electricity costs (but lower health and environmental costs).

In Bill 100, Ontario created a new form of hybrid electricity market. In this model, the cost of generation from Ontario Power Generation's (OPG's) legacy nuclear and hydro units is fixed, recognizing that they represent a low cost to the system to help offset the higher costs associated with newer forms of electricity generated from gas and renewables. Currently the cost is fixed at an average price of \$45/MWh until 31 March 2008 [12].

As for the cost of new generation, the costs for Renewables I have been reported at about \$80/MWh. The structuring of Renewables II, for which there is a limit specified of 115% of the cost of the first 450 MW, suggests that there are concerns with the cost of renewables as their penetration increases. This philosophy has been extended to Renewables III in which the province is only committed to the first 90 MW unless the price of the remaining projects also remains within the 115% band.

The costs for the winning projects from the CES RFP have been reported as less than \$78/MWh based on an average gas price over the past two years. But the fact that less than the full 2500 MW was contracted, even though there were a multitude of bids, coupled with recent increases in gas prices, does suggest some concern with the future costs of new gas generation.

Meeting the Need - An Alternative Scenario

The government plan to replace coal is a very aggressive plan, which is not without risk. Clearly a scenario in which some nuclear contributes to this objective will take the pressure off delivering such a large amount of gas and co-generation at a competitive price. The currently shut down units at Bruce (1 & 2) and Pickering (2 & 3) represent viable options for increasing generation at a reasonable cost, and most of all, once in service, the cost from these nuclear units remains stable for the remainder of their lives, as they are not subject to fluctuations in fuel prices.

Therefore, an alternative scenario to achieving the replacement of coal can be as shown in *Table 2*. This shows that including Bruce Units 1 & 2 and Pickering Units 2 & 3 provide a strong case to ensure that the need to replace the coal units is achieved. This scenario continues to include some aggressive assumptions and still has a measure of risk, but at a level that is lower than the government plan. Some of the continuing more optimistic assumptions follow:

- Wind is assumed to achieve the maximum capacity value based on the IESO study (40%), rather than the more conservative value assumed in the IESO forecast (10%). (Note that this assumption in the IESO 2005 10-Year Outlook requires the restart of Bruce Units 1 & 2 to meet demand).
- Demand side management is assumed to achieve a significant target, which may not be achieved in the necessary time frame, based on the results of the recent CES RFP.
- Renewables II is assumed to achieve its specified 1000 MW even though there is no guarantee that more than 450 MW will be accepted in the terms of the RFP.
- Significant co-generation and gas is assumed but pricing and resource adequacy issues are likely to have an impact on gas decisions.

Timing is also a critical issue. The IESO reports in its 2005 10-Year Outlook that to meet the schedule for replacement requires that the key decisions on new supply be taken prior to the end of 2005 and that any delay will result in a need to keep operating the coal units until all of the supply and generation projects required are successfully implemented.

The Role of Nuclear Power

Nuclear power continues to be the backbone of the Ontario electricity system. It represents just over one-third of the system by capacity (*Table 1*) and just under 50% on an energy basis. The return to service of Pickering Unit 4 and Bruce Units 3 & 4 (approximately 2000 MW) has been an important element of the system being able to continue to meet demand.

The current fleet of nuclear reactors in Ontario are aging and are nearing their natural end of life. *Figure 1* shows that the currently operating units start to drop off towards the end of the 10-year period and that, within 20 years, most of the fleet will have to be replaced. The first currently operating nuclear unit to reach

its natural end of life will be Bruce Unit 3 in 2009. However, the current fleet of nuclear reactors have the ability to be refurbished and have their lives extended by another 25 to 30 years. Pickering Unit 4 has already been restarted and Pickering Unit 1 is underway. The decision on Bruce Units 1 & 2 is imminent. The success of this project will set the path for an ongoing refurbishment of the entire fleet.

The plan to replace coal described above is very challenging. Imagine what would happen if the 10 000 MW of operating nuclear units would also have to be replaced. It should also be noted that the fleet of nuclear plants does not contribute any carbon into the atmosphere. It would be extremely difficult to replace these units, considering their total contribution to generation with alternatives that are also non-carbon emitting.

In a speech to the Canadian Club on 2 May 2005 [13], the Energy Minister recognized the need to move forward on this issue. He said, "*The toughest issue that must be grappled with is the future of nuclear energy.*" "*We cannot and must not postpone the decision on new nuclear any longer. We need to begin to make some decisions through an open and public debate.*" He then went on to direct the OPA to seek advice on this issue as part of its planning process so that government can move forward with regards to nuclear energy.

The OPA has recently begun the process of securing this advice. In a Request for Proposals issued 4 July [14], it has requested inputs to this process with the objective of delivering a report to the Minister on the issue of Supply Mix by 1 December 2005. This report needs to address conservation targets, renewable energy targets and then the appropriate mix of electricity for the balance of the system. Therefore, this is an important time for the province as it considers its options. The outcome of the work will have far reaching consequences on the form of future generation for the foreseeable future.

The results of the recent RFP processes to date have demonstrated that more generation is possible but that, as the amount of renewable and gas generation increases, cost may become a factor. As demonstrated in the study on coal replacement, refurbished nuclear is an economic option, and a mix of gas and refurbished nuclear was considered the best option for the future. Thus it becomes clear that the nuclear fleet must be refurbished and stays in service as long as possible.

Planning for Growth

Replacing coal is not the only requirement on the system. Assuming that the above plan to replace coal succeeds, and that all of the currently operating nuclear units are refurbished and life-extended, there is still the projected growth in demand to fill (*Figure 1*). This will be equal to approximately 3000 MW over the coming decade and growing into the future. The magnitude of the effort required to replace the coal units with renewable generation, conservation and gas alternatives, and to maintain the existing nuclear fleet in operation is very large. Clearly, planning for growth in addition to meeting these requirements will be a significant challenge.

Nuclear new build units should be one of the options considered to meet this need, or a portion of it. Nuclear power remains the only large-scale option available

that does not produce greenhouse gases. Therefore, consideration should be given to fuel the growth with a combination of nuclear, gas and renewables to maintain a healthy and cost effective system. On this basis, a new build nuclear project to demonstrate next generation nuclear technology should be considered for in service in the 2014/15 timeframe.

Conclusion

Ontario requires an investment of \$25 to 40 billion to replace or rebuild 80% of the electricity system in the province over the next 15 years. The Ontario government has taken significant action as it moves forward on a number of initiatives to meet this requirement.

After completing a study that demonstrates the negative environmental and health impacts of burning coal in the province, the government has moved ahead with an aggressive plan to replace all of this coal generation by 2009. After a review of this plan, this Paper has concluded that replacing the existing coal units with less polluting alternatives is difficult, but achievable. In addition to the base scenario proposed by government, an alternative scenario with the addition of the restart of the currently idled nuclear units is proposed as a lower risk option, with an improved economic and environmental outcome.

Nuclear power remains the backbone of the Ontario electricity generation system and will continue to do so for the foreseeable future. Refurbishment of the fleet is essential to meeting the requirements of the system in the most environmentally benign way. New build should be considered as an option to meet the growth in electricity demand over the next decade and beyond.

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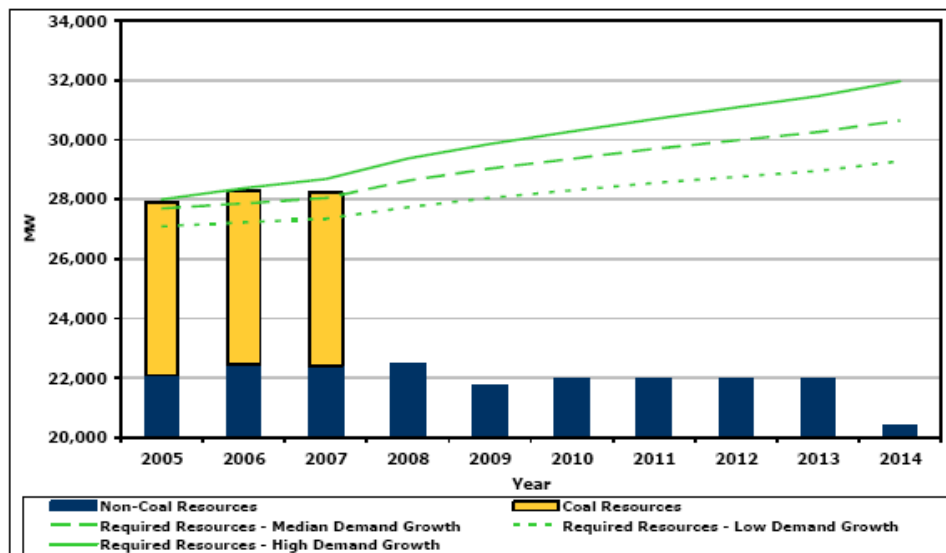
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Figures and Tables

Figure 1
Resource Adequacy Outlook – Annual Peak



Source: IMO 10-Year Outlook, 29 April 2004.

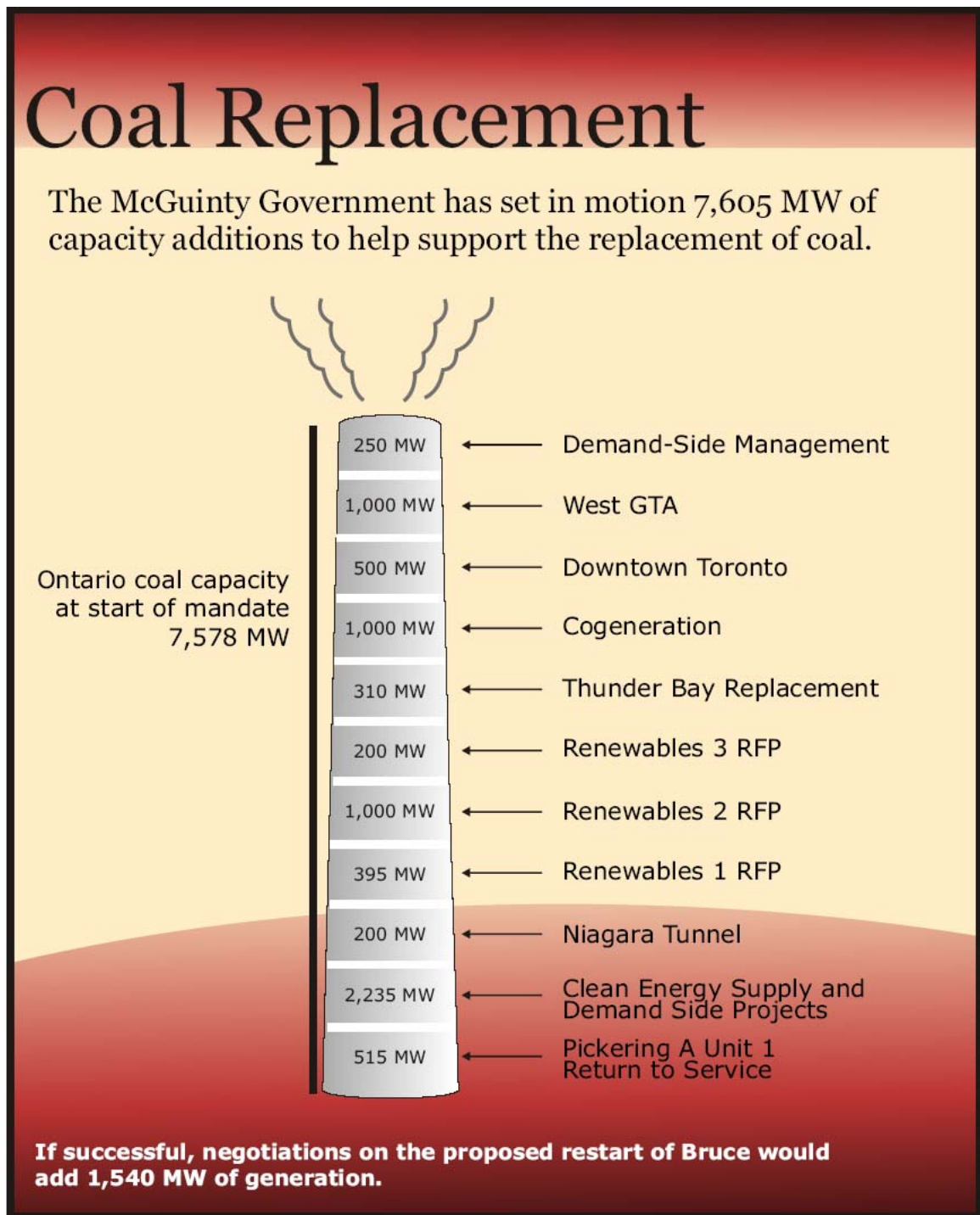
Table 1
Existing Installed Generation Resources

	Total Capacity (MW)	Number of Stations
Nuclear	10 882	5
Coal	6434*	4
Oil/Gas	4976	20
Hydroelectric	7756	67
Miscellaneous	66	2
Total	30 114	98

* Lakeview Generating Station has been shut down earlier in the year and as such, is not included in this value.

Source: IESO 18-Month Outlook, 27 June 2005.

Figure 2
Coal Replacement Plan



Source: Ontario Ministry of Energy Press Release, 15 June 2005.

Table 2
Coal Replacement – An Alternative Scenario

Generation / Project	Capacity (MW)
Pickering Unit 1	515
Clean Energy Supply	2235
Renewables I RFP*	206
Renewables II RFP*	400
Renewables III RFP*	140
Bruce Units 1 & 2**	770
Pickering Units 2 & 3	1030
Co-generation	1000
Gas	1100
Demand Side Management	200
Total	7596

* Wind generation is assumed at 40% capacity value consistent with the IESO study.

** While Bruce Units 1 & 2 represent 1540 MW, only half is considered as a replacement for coal as the other unit will replace Bruce Unit 3 as it goes down for refurbishment. It is then assumed that over the next 15 years there will always be one unit from Ontario's nuclear fleet down for refurbishment as the fleet is refurbished in sequence.